Phase 3A: Recommended Studies on Pacific Lamprey and White Sturgeon to Inform the Portland Harbor Ecological Risk Assessment (ERA) and NRDA

Introduction

Recognizing our interrelated responsibilities under CERCLA, the response agencies, the natural resource trustees, and the Lower Willamette Group (LWG) have endeavored to identify and resolve remaining information shortfalls and knowledge gaps that are impeding comprehensive response and restoration decision making at the Portland Harbor National Priorities List Site. The value of coordination of investigations such that our respective CERCLA response and restoration responsibilities can be simultaneously satisfied was exemplified by the chinook spring-run young of the year effort completed last spring, generally agreed upon as a "success." The third, and possibly final, round of data collection will soon be underway for the Site.

The ultimate goal of this data gathering effort should be to complete assembly of an adequate information set which will be necessary to support both risk management decisions and the trustees' injury and restoration scaling decisions. Such an approach can also facilitate universal legal settlement of hazardous substance release liabilities at some point in the future.

The Sturgeon Lamprey Task Team

Using the Trustees' February 27, 2006, appendix A as a starting point in discussions, the LWG and state and tribal government partners focused over the past few months on certain remaining ecological and human health risk assessment issues related to Pacific lamprey and white sturgeon. The joint government/LWG Sturgeon Lamprey Task Team was selected by the large LWG and Government management team at an April 26, 2006, meeting. The team was charged to develop a proposal to resolve the issues associated with these unique receptors/resources, and to explicitly address how each proposed data collection effort (1) addresses a data need identified in the Round 3 data gaps memo from the EPA to the LWG, (2) may or may not be replaced by assumptions (e.g. application of safety factors) or existing data from the literature, and (3) will provide results that will inform remedial action decisions.

After additional consideration as to the suitability of the derived information to overall dataset needed to support all CERCLA/NCP decision making requirements, both remedial and restoration, this 'product' was drafted. This product is an attempt to develop an 'I can live with it', 'rough consensus', phased, "if, then, else …" structure of Phase 3A data collection efforts that provide a path forward to fill lamprey and sturgeon data gaps, thereby reducing uncertainty regarding their risk assessment. If significant risk is demonstrated in the proposed Phase 3A studies, then additional Phase 3B studies (see separate document) may be warranted.

This suite of experiments proposed in Phase 3A below should proceed in the immediate future and should take advantage of the present field season, as practicable.

Juvenile Lamprey Studies

SPECIFIC QUESTION 1A: ARE JUVENILE LAMPREY EXPOSED TO SIGNIFICANT RISK FROM COPECs AT THE SITE?

Suggested Study:

Collect ammocoetes and macropthalmia from throughout the ISA. Analyze whole body composite tissue samples for concentrations of COPECs; compare these data to results from lab sensitivity studies on juvenile lamprey (Specific Question 2 below) and published toxicity reference values (TRVs). Also collect co-located sediment samples for Specific Question 1B below.

Notes:

Efficiency of collection of ammocoetes and macropthalmia may be improved by attempting to identify suitable habitat for these life stages based on sediment profile index data and sediment grain size data.

Data Need Addressed:

Exposure of ammocoetes and macropthalmia to contaminants in the ISA. This also will allow potential correlations between body size / life stage and (a) sediment structure (e.g., percent fines)(see Specific Question 1B below), and (b) and tissue contaminant concentration.

Study Assumptions:

- All contaminants in ammocoetes collected in ISA originate from within the Site.
- Lamprey collected in the ISA have resided in the ISA for a time sufficient for the levels and composition of contaminants in their tissue to accurately reflect exposure to ambient concentrations of contaminants in sediment, water and food in the ISA.

Application of study results to Remedial Decision:

Tissue contaminant levels can be used in combination with TRVs protective of lamprey (see Question 2 below) to:

1. Calculate Hazard Quotients (HQs) for COPECs,
2. Back-calculate to water and sediment clean-up levels using a model (e.g. BSAF) or empirical data

Study design considerations:

Sampling ammocoetes in deepwater habitats like the LWR presents challenges because of the difficulties of capturing infaunal organisms with highly patchy distributions in deep water. However lamprey ammocoetes have successfully collected in the Great Lakes using a modified

electrofisher with suction (Bergstedt and Genovese 1994). Therefore, we anticipate that this method can be applied successfully, perhaps with some modification, in the lower Willamette River.

- An appropriate mass of tissue for each tissue composite will depend on:
  - 1. The suite of contaminants of potential ecological concern (COPECs) that will be analyzed, and
  - 2. detection limits desired, and analytical methods employed.
- The QAPP should require that compositing of samples obeys guidelines regarding variation in body size.

- The number of composites that should be collected should depend mainly on the:

  - 1. accuracy with which we want to estimate concentrations of COPECs, (e.g. 95% CI width = ± 25% of mean), and

  - 2. how the data will be used in the Line of Evidence and Weight of Evidence Ecoframework to assess risk (e.g., will the upper limit of the 95% confidence interval be used as an estimate of risk/exposure?).

- The desired sample size can be estimated based on the two factors above and an estimation of the coefficient of variation in tissue concentrations of specific COPECs of interest.

- The coefficient of variation (CV) in concentrations of COPECs in the clam tissue collected in Round 2 is likely to be the best site-specific estimate of the coefficient of variation in concentrations of COPECs in lamprey tissue. The CV) in concentrations of COPECs in the clam tissue collected in Round 1 (n=3 composites) was 50%.

- Sampling locations for ammocoetes should be appropriately stratified. Variables for consideration:

  - 1. Location (e.g. among Areas of potential Concern [AOPCs]),

  - 2. River mile (ammocoetes near the downstream boundary of the ISA must be exposed, on average, to contamination in the ISA for a longer period of time than ammocoetes further upstream, since ammocoetes move passively),

  - 3. Water depth and location (e.g. shallow vs. deep water, and near shore versus within the ship channel)

- 4. Habitat / substrate structure based on previously collected sediment profile imaging data and sediment characterization (e.g. sediment samples collected for bioassays),

- 5. Season (winter vs. summer) because of variation of water flow volume and consequent changes in surface water (and possibly groundwater and transition zone water) concentrations.

- When considering design, it should be noted that it is not feasible to compare tissue concentrations of COPECs in lamprey collected in the ISA to those of upstream reference samples. (see Appendix 1).

SPECIFIC QUESTION 1B: WHAT ARE THE HABITAT PREFERENCES OF YOUNG LAMPREY IN RELATION TO BODY SIZE AND STAGE OF DEVELOPMENT (AMMOCOETES VS. MACROPTHALMIA)?

Habitat preferences of young Pacific lamprey are poorly understood; however, there is some evidence that ammocoetes prefer relatively fine-grained, silty habitat whereas macropthalmia prefer coarser substrate. Because the concentration and bioavailability of contaminants may vary in relation to such aspects of the physical structure of the substrate, risk to lamprey should be evaluated by collecting ammocoetes and macropthalmia across these habitat types.

Suggested Study: Identify and categorize substrate types in the Site using (1) sediment profile imaging data, and (2) sediment grain size. Collect samples of ammocoetes among these habitats using a stratified sampling approach (done during investigation of Question 1A above) to determine whether ammocoete presence, absence or density varies at the Site in relation to physical parameters such as depth, temperature and, especially, substrate type.

Data Need Addressed: (1) collection of sufficient number and mass of ammocoetes and macropthalmia to measure levels of COPECs in a number of composite samples (number of composites to be negotiated) in the study discussed below, and (2) documents whether ammocoetes and/or macropthalmia exhibit substrate/habitat preference.

Assumptions Necessary for Data Interpretation: Ammocoete collection methods are equally efficient in all habitat types.

How Can Data Inform Remedial Decision?:

If lamprey exhibit habitat preference, then mean risk to lamprey throughout the Site can be calculated based on the (1) relative abundance of each habitat type in the Site, and (2) the relative use by lamprey of each habitat type. To do so, however, composite samples should be analyzed (see study below) for each habitat type since contaminant levels and composition may differ among habitat types (based on previous data, e.g. benthic interpretative approach, etc.).

Utility and Feasibility of Using Assumptions Rather than Collecting Empirical Data:

If ammocoetes and/or macropthalmia do exhibit habitat / substrate preference, one could assume that all lamprey could use the habitat type that poses the greatest overall risk. However, this would be an overly conservative assumption, and not warranted. One could also assume that all habitats are used equally; however, because it is easy to quantify both habitat type and sampling effort, there is no reason to make this assumption. One also could assume that habitat use and preference by ammocoetes is the same as that for macropthalmia, but, again, there is no reason to do so because (1) it is easy to quantify both habitat type and sampling effort in relation to the number of ammocoetes vs. macropthalmia captured.

SPECIFIC QUESTION 2: WHAT IS THE TOXICITY OF SITE-RELATED COPECs TO JUVENILE LAMPREY?

Suggested Study:

Obtain ammocoetes (either cultured in the lab or captured at "clean" sites in the Pacific Northwest) and conduct toxicity studies with COPECS. Measure endpoints related to lamprey growth, survivorship and mortality.

Data Need Addressed:

Sensitivity of ammocoetes and macropthalmia to COPECs.

Study Assumptions:

- Acute lab exposure studies are representative of actual field contaminant levels and exposure durations.
- Relative acute toxicity is predictive of relative chronic toxicity.

Application of study results to Remedial Decision :

Results will indicate sensitivity of lamprey ammocoetes and macropthalmia to COPECs relative to other fish species.

Design Considerations:

Ammocoetes may potentially be obtained at NOAA's Northwest Fisheries Science Center or Columbia River Lab in Cook, WA.

Toxicity studies should employ 96-hour acute toxicity studies on a set of COPECS identified from recent analyses on ammocoetes, clams and/or mussels collected during Round 2 benthic sampling. Studies on ammocoetes should be paired with identical studies on a well known "reference" species (e.g., rainbow trout, fathead minnow and or other potentially species known

to be more sensitive to specific COPECs) to assess whether ammocoetes are more or less sensitive than the reference species.

Adult Lamprey Studies

SPECIFIC QUESTION 3: WHAT IS THE RESIDENCY TIME AND USE OF THE SITE BY ADULT LAMPREY?

Suggested Study:

Capture adult lamprey downstream of ISA, tag them with acoustic transmitters and return tagged fish to capture location. Determine their within-ISA residency time and potentially document movement patterns and site use (see Design Considerations below). In addition, capture, radio-tag and track adult lamprey at Willamette Falls to document their additional residency time, if any, in the ISA.

Notes:

Importantly:

1. Even with a coefficient of variation of 75 % and an α-level of 0.05, residency time can be estimated with a sample size within the budget and experimental design suggested above.

2. The overall estimate of mean residency time should be an unbiased estimate of residency time (throughout the year).

3. To the extent that we want to be protective of lamprey and sturgeon (i.e. protect them at the individual level), we are less concerned about mean exposure, and more concerned about maximum exposure. This study will provide a very good assessment of the variability in exposure duration, including an estimate of maximum residency time.

4. An alternate approach of comparing tissue concentrations in adult lamprey collected in the ISA to those of lamprey collected at "reference" sites elsewhere in the Willamette and/or Columbia River is not feasible based on statistical considerations (see Appendix 2 attached).

Data Need Addressed:

Exposure of adult lamprey to COPECs from the ISA.

Study Assumptions:

- Capture and tagging of adult lamprey with acoustic and radio-transmitters will not alter their behavior relative to untagged adult lamprey.

Application of study results to Remedial Decision:

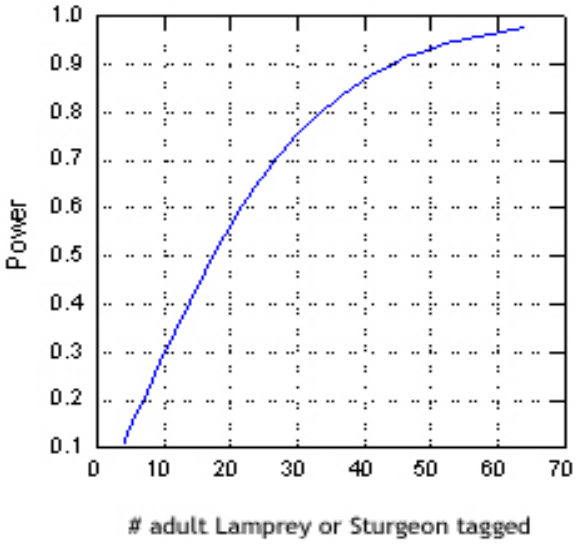
Duration of exposure in combination with data regarding rate of uptake of COPECs from lab exposure studies (if done) and/or other existing data may allow risk from COPECs to be estimated. In turn, these risk estimates may be used to determine whether lamprey are risk drivers for specific COPECs for remedial actions in the ISA.

Design Considerations:

1. *Estimation of residency time using* tagged lamprey requires a minimum of two "gates" (electronic receivers on each side of the Willamette River), one at the upstream boundary of the ISA and another at the downstream boundary of the ISA, that receive and electronically record each time a lamprey enters or leaves the ISA. Placement of additional gates between the upstream and downstream gates would provide additional data regarding lamprey movements and site/habitat use within the ISA. The resolution of these data would depend on the number of additional gates deployed.

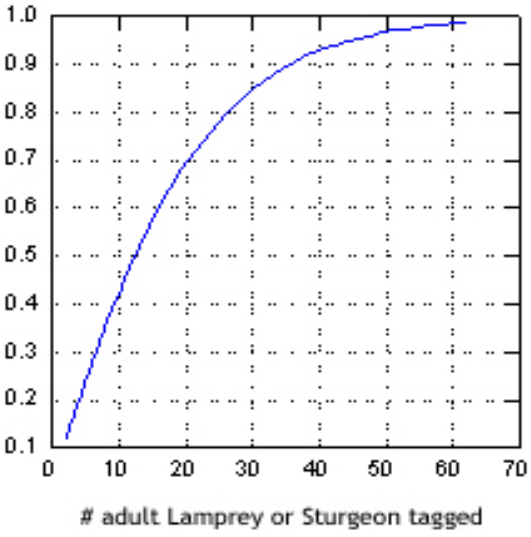
2. *Sample Size Necessary for Telemetry Studies:* Power analyses designed to estimate the sample size of adult lamprey or sturgeon for tagging required to estimate mean residency time with a confidence interval that is 25% of the mean varies from approximately 15 to 45 depending upon the variability in the data (coefficient of variation), and the appropriate α-level chosen (0.05 or 0.10) as indicated in the graphs below.

Power Curve (Alpha = 0.05000)



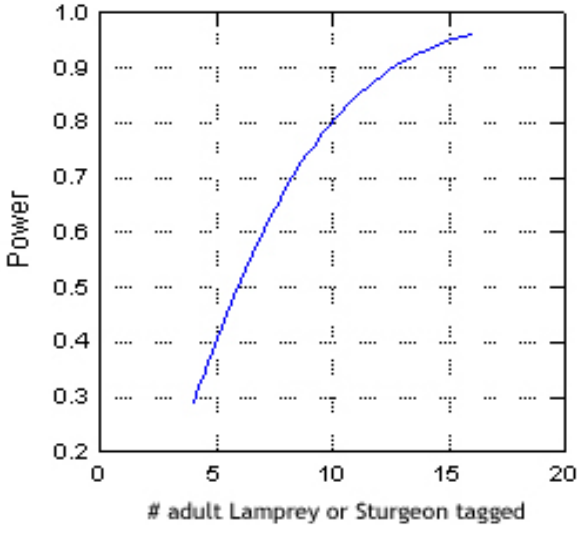
Coefficient of Variation 50%
Width of Confidence interval =25%
α=0.05

Power Curve (Alpha = 0.10000)



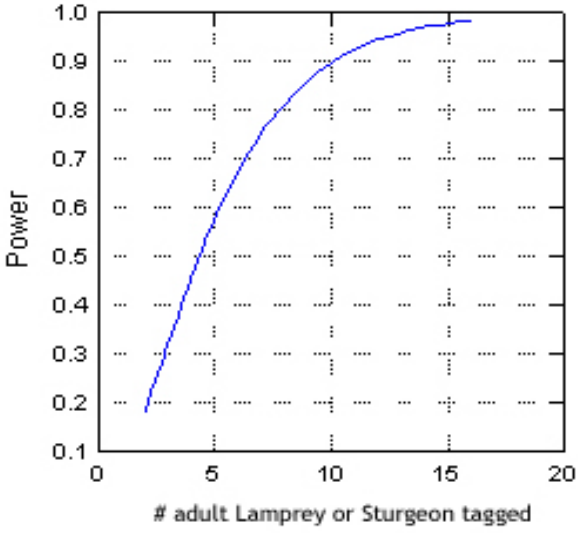
Coefficient of Variation 50%
Width of Confidence interval =25%
α=0.10

Power Curve (Alpha = 0.05000)



Coefficient of Variation 25%
Width of Confidence Interval=25%
α=0.05

Power Curve (Alpha = 0.10000)



Coefficient of Variation 25%
Width of Confidence Interval=25%
α=0.10

White Sturgeon (Acipenser transmontanus)

The white sturgeon is a mainly bottom-dwelling fish that feeds on clams and other bottom-dwelling biota, but increasingly on other fish as it grows to larger size, has direct contact with bedded sediment and is very long-lived (up to 100 years). Tissue concentrations of some bioaccumulative contaminants, including some metals, can continue to increase throughout the life of long-lived fish species and may accumulate to levels of potential concern. The interrelated issues of exposure and physiological sensitivity remain unresolved regarding this species.

SPECIFIC QUESTION 1: WHAT IS THE AREA OF USE, SITE FIDELITY AND DURATION OF EXPOSURE TO STURGEON?

Suggested Study:

Capture young (<107 cm), subadult (107-152 cm), and adult (>152 cm) sturgeon in the ISA seasonally and attach acoustic tags to them. Track these fish for at least two years to document residence time in the ISA in relation to fish size (as a proxy for age), and time of year, and habitat use within the ISA. These tags have a lifetime of 7-15 years.

Notes:

Importantly:

1. Even with a coefficient of variation of 75% and an α-level of 0.05, residency time can be estimated with a sample size within the budget and experimental design suggested above.

2. The overall estimate of mean residency time should be an unbiased estimate of residency time (throughout the year).

3. To the extent that we want to be protective of lamprey and sturgeon (i.e. protect them at the individual level), we are less concerned about mean exposure, and more concerned about maximum exposure. This study will provide a very good assessment of the variability in exposure duration, including an estimate of maximum residency time.

4. An alternate approach of comparing tissue concentrations in sturgeon collected in the ISA to those of sturgeon collected at "reference" sites elsewhere in the Willamette and/or Columbia River is not feasible based on statistical considerations (see Appendix 1 attached).

Study Assumptions:

- Behavior of tagged fish does not differ significantly from that of untagged fish; however, because the lifetime of the tags is 7-15 years, any short-term changes in behavior caused by tagging can be assessed by comparing fish behavior shortly after tagging to that exhibited later on.
- Random sample of fish captured for tagging is representative of sturgeon population in Willamette.
- The longer the study continues (e.g. 2 or 3 years vs. only 1 year), the more accurate the estimate of site use will be because of averaging out year-to-year variation.
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Application of study results to Remedial Decision:

Integrate with results from fish age and tissue concentration analysis (see Question 2 *Application of study results to Remedial Decision* below) to evaluate risk and compute protective sediment and water clean up levels.

SPECIFIC QUESTIONS 2:

ARE CONCENTRATIONS OF COPECs IN AXIAL MUSCLE (TISSUE PLUG) CORRELATED WITH THOSE IN WHOLE BODY SAMPLES IN JUVENILE AND SUBADULT STURGEON,

ARE CONCENTRATIONS OF COPECs IN AXIAL MUSCLE AND/OR WHOLE BODY SAMPLES CORRELATED WITH BODY SIZE IN JUVENILE AND SUBADULT STURGEON, AND

ARE CONCENTRATIONS OF COPECs IN AXIAL MUSCLE SAMPLES CORRELATED WITH BODY SIZE IN ADULT STURGEON?

Suggested study:

While capturing sturgeon for the acoustic tagging study above, capture, collect, and take two tissue plugs from each sturgeon captured, including all adult (>152 cm) sturgeon. Also, collect whole-body samples of young and subadult sturgeon (n=25?).

Analyze (1) individual whole-body tissue, tissue plugs, and stomach content samples from juvenile and subadult sturgeon, and (2) tissue plugs from adult sturgeon for a specific suite of COPECs (suggested methods for choosing COPECs discussed below).

Data Need Addressed:

Both whole body and tissue plug (muscle) concentrations of COPECs will indicate relative degrees of exposure of juvenile and subadult (prebreeder) sturgeon to COPECs. Concentration of COPECs in muscle plugs from adults may be used to estimate concentrations in whole body samples based on relationships derived from whole body and tissue plug samples collected from young and subadult sturgeon

Study Assumptions:

None.

Application of study results to Remedial Decision:

Juvenile and Subadult Sturgon

Compare tissue concentration data to appropriate risk screening values. Consider the contribution from the site using the data regarding percentage of time that fish of equivalent size (age) spend in the ISA from the telemetry described above. Take appropriate remedial or risk management actions to reduce exposure of sturgeon with unacceptable risk.

Adult Sturgeon

Evaluating potential risk of contamination in the ISA to adult sturgeon is more difficult than in the case of juvenile and subadult sturgeon. We can not collect and analyze whole body samples of adult sturgeon; nor does it appear possible to develop a model (e.g. food web model) to estimate adult tissue concentrations. However, analyses of previous data regarding fillet (CRITFC, n=16), but not whole body (CRITFC, n=8), tissue samples from sturgeon collected in the lower Columbia River in 1996-1998 (EPA 2002) and in the lower Willamette River in 2003 (ODHS unpubl. data) indicate a significant positive relationship between the tissue concentration of many organic COPECs (as well as a few nonorganic COPECs such as mercury) and body size (length and/or mass) as shown in Table 2 which follows this section.

Thus, it may be possible to develop either or both of two regression models to estimate adult whole body concentrations of COPECs by using whole body and tissue plug data collected from juvenile and subadult sturgeon. The assumption underlying both modeling approaches is that the relationships developed using data from juvenile and subadult fish can be applied to adult sturgeon.

Model 1.

Conduct regressions of whole body tissue concentrations of COPECs on body size (length and mass). If significant relationships exist, then use these regression equations to estimate the whole body concentration in larger adult sturgeon.

Model 2.

Conduct regressions of concentrations of COPECs in tissue plugs on whole-body concentrations of COPECs for young and subadult sturgeon. If significant relationships exist, then use these regression equations to estimate the whole body concentration in larger adult sturgeon based on the concentrations of COPECs in the tissue plugs of adults.

Design Considerations:

Identify the contaminants of greatest concern based on the tissue data (e.g. those with highest HQ values or greatest daily dose in stomach contents).

A sample size of 25 young and subadult sturgeon should provide sufficient statistical power to accurately determine (1) mean concentrations of COPECs, (2) whether concentrations of COPECs in whole body and/or tissue plug sample from individual fish vary significantly in relation to body size, and (3) whether correlations exist between concentrations of COPECs in whole body versus tissue plug samples in individual fish. Individuals in the sample should be distributed as evenly as possible between sexes and across the available size range of prebreeding sturgeons (approximately 80-152 cm) within the ISA.

Selection of COPECs for analysis should be based on existing tissue data from CRITFC and ODHS.

Given the minimal level of effort required and the potential value of the data, conduct health examinations on individual sturgeon following the U.S. Geological Survey, Biological Evaluation of Status and Trends (BEST)-derived methods. These data will allow us to correlate presence/absence, abundance and kinds of morphological abnormalities with concentrations of analytes in tissues and stomach contents.

Table 2: Results of linear regression of body length(cm) on tissue contaminant concentration (µg/kg) in sturgeon collected in 1996-1998 in the Columbia River (EPA 2002) and in Portland Harbor in 2003 (ODHS, unpubl. data). Significant results ($P<0.05$) are highlighted. R^2 indicates the percentage of variation in contaminant concentration explained by variation in body length.

	ODHS Fillet, n=5		CRITFC-Fillet, n=16	
Contaminant	R^2	One-tailed *t*	R^2	One-tailed *t*
2,4,5-Trichlorophenol			0.828	0.000
2-Chloronaphthalene			0.605	0.000195
2-Chlorophenol			0.88	0.000
4-Chloro-3-methylphenol			0.88	0.000
Alpha-hexachlorocyclohexane	0.696	0.040	0.124	0.091
Aluminum	0.15	0.2595	0.458	0.002005
Antimony	0.132	0.274		
PCBs (total)	0.770	0.0108	0.416	0.00348
Arsenic	0.137	0.27	0.059	0.1825
Beta-hexachlorocyclohexane	0.696	0.040	0.124	0.091
Cadmium	0.132	0.274	0.368	0.0748
Calcium	0.489	0.095		
Chlordane (total)	0.088	0.314	0.138	0.0183
Chromium	0.017	0.4175	0.342	0.00869
Copper	0.421	0.118	0.013	0.339
DDT (total)			0.265	0.0207
Delta-hexachlorocyclohexane	0.547	0.077	0.124	0.091
Dieldrin	0.479	0.098		
Endosulfan I	0.19	0.231		
Endosulfan II	0.192	0.231		
Endosulfan Sulfate	0.083	0.319	0.132	0.101
Endrin	0.08	0.323		
Hexachlorobutadiene			0.222	0.03255
Lead	0.014	0.424	0.056	0.189
Lindane (gamma-hexachlorocyclohexane)	0.696	0.040	0.1235	0.091
Mercury	0.138	0.269	0.2237	0.0322
Nickel	0.013	0.428	0.042	0.224
4,4-DDD	0.022	0.406	0.456	0.0021
4,4-DDE	0.096	0.306	0.3593	0.0071
4,4-DDT	0.024	0.422	0.3745	0.006
Pentachlorophenol			0.8792	0.000
Selenium	0.693	0.040	0.012	0.342
Silver	0.132	0.274	0.064	0.172
Toxaphene			0.156	0.065
Zinc	0.127	0.278	0.055	0.191

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Apperndix 1. Sample Size Necessary for ISA vs. Reference Site Tissue Comparisons for juvenile lamprey

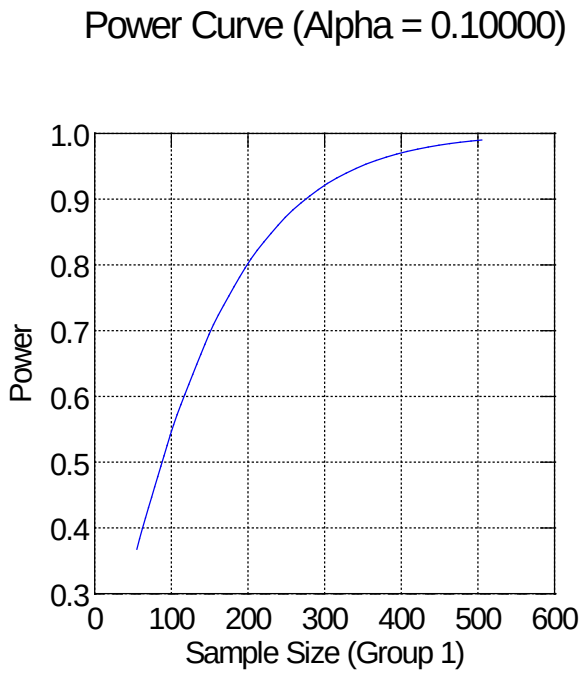
No geographically relevant data currently exist regarding the variability of tissue contaminant concentrations for lamprey ammocoetes or macropthalmia. Variation in tissue concentrations of contaminants in sculpin from Portland Harbor collected during Round 1 are likely to be the best indicator of variability in tissue concentrations of contaminants in lamprey ammocoetes and macropthalmia because sculpin are the most ecologically similar species for which we have such data from Portland Harbor. That is, sculpin have small home ranges. However, the clam tissue data from Round 2 should be evaluated as soon as they are available as clams are ecologically more similar to lamprey than are sculpin. .However, until that time, analysis of Round 1 sculpin tissue data indicates that the mean coefficient of variation is 94% (Table 1), and some important COPECs such as DDD, DDE and DDT exceed 200%.

Table 1. Mean, standard deviation (SD) and coefficient of variation (CV) in the concentration of contaminants in sculpin collected in Round 1 by the LWG. Analytes listed are those for which toxicity reference values (TRVs) have been selected by the LWG

Analyte	Mean	SD	CV
2,3,7,8-TCDD	0.00026	0.000117	45.0
4,4'-DDD	27.3	63.8	233.5
4,4'-DDE	59.2	126.0	212.7
4,4'-DDT	102.5	330.0	321.9
4-Methylphenol	31.6	6.4	20.4
alpha-Endosulfan	3.4	4.0	118.5
alpha-Hexachlorocyclohexane	2.5	2.2	87.1
Antimony	1.9	1.7	87.9
Arsenic	204.6	45.9	22.4
beta-Endosulfan	3.0	3.1	104.3
beta-Hexachlorocyclohexane	5.4	2.7	49.8
Bis(2-ethylhexyl) phthalate	1615.0	5677.9	351.6
Cadmium	9.3	5.3	56.7
Chromium	122.3	80.6	65.9
cis-Chlordane	5.2	4.0	78.0
cis-Nonachlor	5.9	2.0	34.5
Copper	1245.5	185.6	14.9
delta-Hexachlorocyclohexane	2.5	2.2	89.1
Dieldrin	8.5	6.1	71.1
Di-n-octyl phthalate	319.2	60.1	18.8
Endosulfan sulfate	3.5	3.7	107.4
Endrin	6.4	9.9	154.5
Endrin aldehyde	3.5	2.6	75.8
gamma-Hexachlorocyclohexane	3.5	2.9	81.7
Heptachlor	2.7	2.9	106.5
Heptachlor epoxide	3.1	2.6	84.2

Hexachlorobenzene	17.8	12.8	72.0
Hexachlorobutadiene	5.0	8.2	166.0
Hexachloroethane	6.1	9.5	154.8
Lead	143.9	206.6	143.6
Mercury	41.6	15.1	36.2
Methoxychlor	3.5	2.0	57.7
Nickel	247.4	102.2	41.3
Selenium	269.2	47.1	17.5
Silver	2.0	1.3	64.6
Thallium	4.3	2.2	51.0
trans-Chlordane	3.3	2.4	70.6
Zinc	15415.4	1270.8	8.2
		Mean	**94.148**
		SD	**78.1921**

The sample size necessary to detect a 25% difference with 80% power and 90% confidence (i.e. $\alpha = 0.10$) is approximately 200. Even if this relatively high level of uncertainty was deemed acceptable, this indicates that 200 composite samples would have to be collected from each location (ISA and reference site). Ammocoetes weigh, on average about 1 gram (based on masses of ammocoetes collected during the Round 2 clam collection). Depending on the suite of analytes that would be analyzed, each composite must weigh at least 30 grams, probably more. That's a total of 12000 ammocoetes. In addition, even if a reduced suite of COPECs are analyzed, lab analysis costs alone for 400 samples will be about $1,000,000.



Appendix 2.

Sample Size Necessary for ISA vs. Reference Site Tissue Comparisons for adult lamprey and sturgeon

In order to estimate the sample size necessary in each of two (or more) samples for the purpose of comparing mean tissue concentrations of contaminants, we need to specify three parameters: (1) the magnitude of difference between means (effect size) that we want to be able to detect , (2) the degree of statistical confidence that we want to have in our results (e.g. 95%, i.e. $\alpha = 0.05$), and (3) the variability in the data from the statistical populations that we plan to sample. The first two parameters are not addressed by data, but instead are set by experimenters and/or policy makers based on the degree of uncertainty that is deemed to be acceptable/unacceptable. The third parameter is empirically derived from previous data collected from the populations in question, if such data exist. If such data do not exist, then similar data from other sites, species, etc. may be used in place of site-specific data if this is deemed acceptable. The last resort is to make a best guesstimate of the expected variability in parameter in the populations in question. Fortunately, previous data have been collected regarding tissue contaminant levels in sturgeon and lamprey from the Columbia River Basin, including the Willamette River (EPA 2002, ODHS 2003 unpublished data).

EI screened these data as well as all additional fish tissue data collected by the LWG in Round 1 of the Portland Harbor RI against Toxicity Reference Values for fish promulgated by the LWG in the 9 September 2005 draft of the Preliminary Risk Evaluation (Appendix B, Table 4, Windward 2005). All COPECs with hazard quotient values greater than 1 are included in Tables 3 and 4 below. Variability in tissue concentrations was evaluated by calculating the coefficient of variation (standard deviation/mean) for each study, fish species, type of tissue (whole body vs. fillet), and specific contaminant (Tables 3 and 4). Two points are noteworthy.

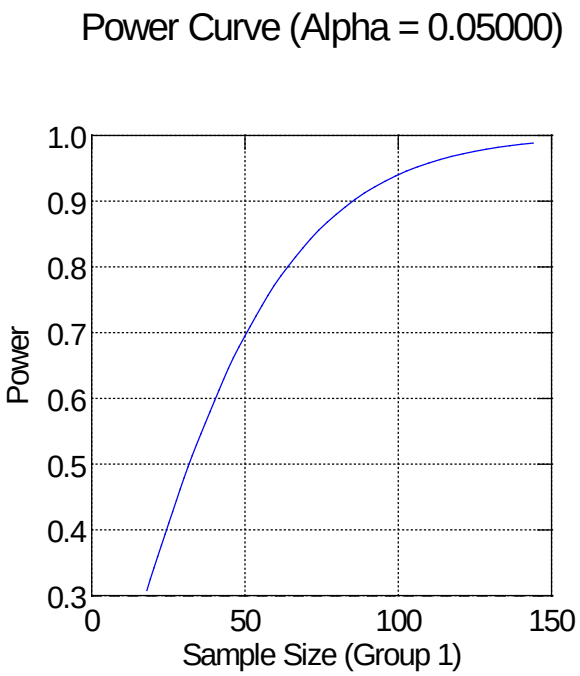
First, variability in lamprey samples is lower (approximately 20%-40% coefficient of variation) than in sturgeon samples (approximately 50% coefficient of variation) probably because lamprey samples were composites whereas sturgeon samples were from individual fish; thus, variability in tissue concentrations in individual lamprey must be considerably greater; further, because the Programmatic Workplan (Integral Consulting et al. 2004) requires that risk to lamprey be assessed at the individual level, we should assume a higher level of variability in individual lamprey while developing sampling designs for future RI and/or NRDA studies.

Second, the magnitude of variability in tissue concentrations varies considerably among different COPECs; however, some COPECs that are likely to be of specific interest such as Total PCBs and Total DDT are more variable than the average for all COPECs (see Tables 3 and 4 below).

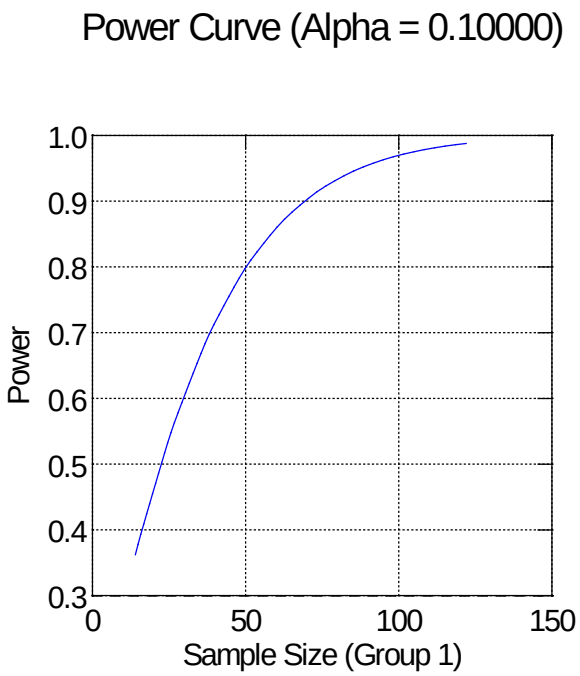
Given the results above, I think it is fair to say that the “average” COPEC will exhibit a coefficient of variation (CV) of 50%, and that some will vary significantly more than that. During the Sturgeon Lamprey Task Team’s conference call earlier today (26 May), LWG’s consultants (Mike Johns and Mark Lewis), the tribal consultants (EI and CRITFC), and the government partners attending the call agreed that it is reasonable to require that we be able to detect a 25% difference in tissue contaminant levels in sturgeon and lamprey collected in the ISA

versus one or more “reference sites. Therefore, I conducted some simple estimates of the sample size necessary to detect a 25% difference between mean tissue concentrations of contaminants that have a coefficient of variation of 50%. The results are presented in the power curves below. Power is the probability of detecting the specified difference between means as a function of sample size, e.g., in the plot below, a sample size of 50 results in a power of 0.7 (i.e., a 70% probability of detecting a 25% difference that actually exists between two means, with 95% confidence [i.e. $\alpha = 0.05$]).

Although we have not discussed or agreed upon a level of power and statistical significance that we think is necessary for the design of a study to compare mean tissue contaminant levels in sturgeon and/or lamprey in the ISA versus reference sites, I think it is reasonable that we would not accept a power less than 0.8 (and probably 0.9) or an alpha-level greater than 0.10, as reflected in the latter power curve above. This power curve indicates that we would need to collect and analyze a minimum of 50 lamprey and 50 sturgeon at each sampling location, i.e. in the ISA and at each reference site. As a result, this approach seems impractical and ill-advised scientifically, politically and financially given the level of uncertainty in the results, especially for contaminants with higher CVs than 50%, the number of fish that would need to be sacrificed, the logistical difficulties of obtaining the requisite number of fish samples, and the total cost of the field effort and associated lab analyses.

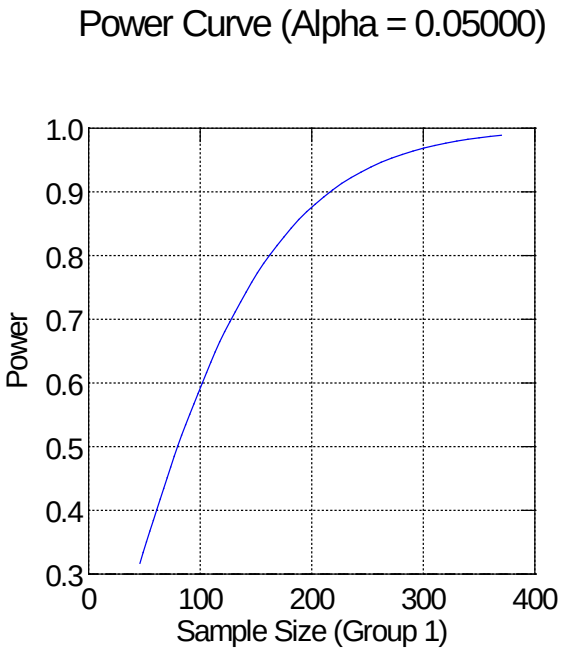


25% difference between means

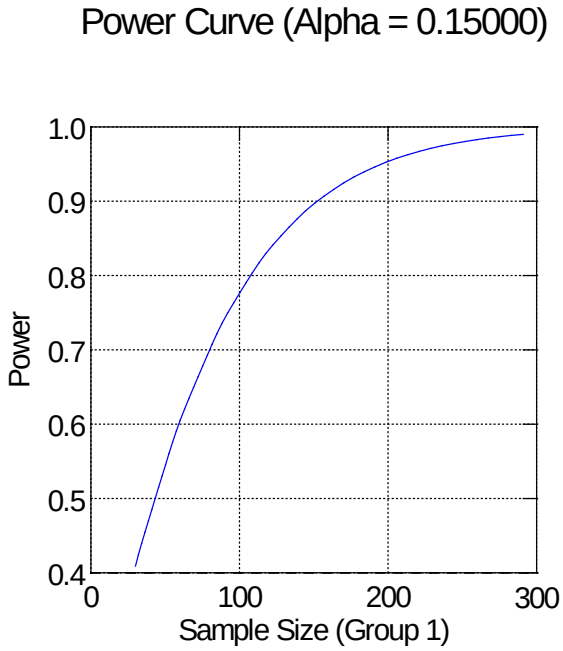


25% difference between means

50% coefficient of variation



50% coefficient of variation



25% difference between means
80% coefficient of variation

25% difference between means
80% coefficient of variation

Table 3. Standard deviation (SD), mean, and Coefficients of variation (CV) in contaminant concentration in whole body (WB) and fillet (FS) tissue in Pacific lamprey collected in the lower Columbia River (CR) and lower Willamette River (Willamette Falls [WF]) in 1996-1998 (Columbia River Intertribal Fish Commission[CRITFC]) and in 2003 (Oregon Dept. Health Services [ODHS]).

	Pacific lamprey																	
Contaminant	FS SD CRITFC	FS MEAN CRITFC	FS CV CRITFC	WB SD CRITFC WF	WB MEAN CRITFC WF	WB CV CRITFC WF	WB SD CRITFC CR	WB MEAN CRITFC CR	WB CV CRITFC CR	WB SD CRITFC Total	WB MEAN CRITFC Total	WB CV CRITFC Total	WB SD ODHS	WB MEAN ODHS	WB CV ODHS	WB Total SD	WB Total MEAN	WB Total CV
2,4,5-Trichlorophenol	14.5	984.3	1.5	459.6	730.7	62.9	804.0	851.7	94.4	589.4	791.2	74.5				589.4	791.2	74.5
2-Chloronaphthalene	0.6	49.3	1.2	16.4	29.8	55.1	1.0	19.0	5.3	14.1	26.2	53.7				14.1	26.2	53.7
2-Chlorophenol	14.5	984.3	1.5	327.6	593.2	55.2	804.0	851.7	94.4	495.3	679.3	72.9				495.3	679.3	72.9
Alpha-hexachlorocyclohexane	0.1	1.9	3.0	0.7	2.6	28.6	0.1	2.0	2.9	0.7	2.4	27.6	0.0	0.9	4.5	0.9	1.9	46.2
Aluminum	0.0	1000.0		592.2	1533.3		692.8	1400.0		586.2	1488.9	39.4	279.3	9740.0	2.9	4131.4	4435.7	93.1
Antimony	0.0	50.0		0.0	50.0			50.0		0.0	50.0		2325.4	2638.0	88.2	1822.1	974.3	187.0
Arsenic	41.6	313.3	13.3	41.2	311.7	13.2	10.0	160.0	6.3	82.7	261.1	31.7	96.6	706.0	13.7	236.7	420.0	56.4
Beta-hexachlorocyclohexane	0.1	1.9	3.0	0.7	2.6	28.6	0.1	2.0	2.9	0.7	2.4	27.6	0.0	0.9	4.5	0.9	1.9	46.2
Cadmium	10.0	20.0	50.0	15.1	133.3	11.3	10.0	60.0	16.7	38.9	108.9	35.7	15.8	180.0	8.8	47.5	134.3	35.4
Chlordane (total)	17.8	25.2	70.7	13.6	13.7	99.8	22.1	30.4	72.8	18.2	19.2	94.5	0.5	7.0	7.8	17.1	17.0	100.3
Chromium	23.1	113.3	20.4	77.6	131.7	58.9	25.2	123.3	20.4	62.7	128.9	48.7	401.1	828.0	48.4	415.7	378.6	109.8
Copper	173.2	1200.0	14.4	655.5	4283.3	15.3	450.9	4966.7	9.1	660.4	4511.1	14.6	1102.3	13400.0	8.2	4492.0	7685.7	58.4
4,4-DDD	2.5	7.7	32.5	2.6	6.8	38.9	1.2	23.7	4.9	8.7	12.4	70.3	0.8	8.2	10.0	7.4	11.1	66.7
4,4-DDE	4.6	50.0	9.2	6.7	43.5	15.4	5.7	70.7	8.0	14.9	52.6	28.3	2.4	25.5	9.3	17.8	44.2	40.3
4,4-DDT	5.8	31.3	18.4	8.4	15.7	53.5	11.5	15.7	73.5	8.8	15.7	56.0	0.5	5.1	10.5	8.8	12.5	70.7
DDT (total)	5.8	31.3	18.4	8.1	17.1	47.6	12.4	17.8	69.8	8.9	17.3	51.6				8.9	17.3	51.6
Delta-hexachlorocyclohexane	0.1	1.9	3.0	0.7	2.6	28.6	0.1	2.0	2.9	0.7	2.4	27.6	0.2	1.0	21.0	0.9	1.9	44.0
Dieldrin													0.5	5.5	9.2	0.5	5.5	9.2
Endosulfan I													0.6	1.3	43.7	0.6	1.3	43.7
Endosulfan II													1.3	4.0	33.6	1.3	4.0	33.6
Endosulfan Sulfate				0.5	3.2					0.5	3.2	16.2	0.2	3.8	4.6	0.4	3.5	12.8
Endrin													0.0	0.9	4.5	0.0	0.9	4.5
Hexachlorobutadiene	0.6	24.7	2.3	8.3	14.8	55.7	0.4	9.5	3.8	7.1	13.1	54.0				7.1	13.1	54.0
Lead	0.0	10.0		0.0	10.0		25.2	33.3		17.2	17.8	96.5	139.1	111.2	125.1	91.1	51.1	178.0
Lindane (gamma-hexachlorocyclohexane	0.1	1.9	3.0	0.7	2.6	28.6	0.1	2.0	2.9	0.7	2.4	27.6	0.0	0.9	4.5	0.9	1.9	46.2
Mercury	5.8	103.3	5.6	6.3	100.0	6.3	80.0	170.0	47.1	53.4	123.3	43.3	20.3	137.8	14.7	45.3	127.8	35.4
Nickel	0.0	30.0		0.0	30.0		252.4	280.0		177.6	113.3	156.7	8.4	148.0	5.7	140.5	125.7	111.7
PCBs (Total)	11.3	87.0	13.0	12.1	85.2	14.2	26.5	140.0	18.9	31.9	103.4	30.8	4.4	44.8	9.8	38.4	85.4	45.0
Pentachlorophenol	14.5	984.3	1.5	327.6	593.2	55.2	804.0	851.7	94.4	495.3	679.3	72.9				495.3	679.3	72.9
Selenium	20.0	430.0	4.7	77.0	598.3	12.9	26.5	540.0	4.9	68.8	578.9	11.9	151.7	1260.0	12.0	353.1	822.1	43.0
Silver	27.4	75.0	36.5	0.0	100.0			100.0		0.0	100.0		23.5	240.0	9.8	70.8	150.0	47.2
Toxaphene	1.7	58.0	3.0	22.8	72.4	31.4	1.2	58.3	2.0	18.7	67.1	27.9				18.7	67.1	27.9
	1000.0	20000.0	5.0	3386.2	21333.3	15.9		22000.0		2697.7	21555.6	12.5	4645.1	58020.0	8.0	18435.8	34578.6	53.3
Sample Size			n = 3			n = 6			n = 3			n = 9			n = 4			n = 13	
Median			5.3			28.6			8.6			39.4			9.6			51.6	
Mean			14.0			36.2			29.9			48.3			20.1			61.4	
SD			17.5			23.1			35.3			32.2			28.5			40.2	

Table 4. Standard deviation (SD), mean, and Coefficients of variation (CV) in contaminant concentration in whole body (WB) and fillet (FW) tissue in white sturgeon collected in the lower Columbia and lower Willamette Rivers in 1996-1998 (Columbia River Intertribal Fish Commission [CRITFC]) and in 2003 (Oregon Dept. Health Services [ODHS]).

	White Sturgeon											
Contaminant	FW SD CRITFC	FW MEAN CRITFC	FW CV CRITFC	FW SD ODHS	FW MEAN ODHS	FW CV ODHS	FW Total SD ODHS+CRITFC	FW Total Mean ODHS+CRITFC	FW Total CV ODHS+CRITFC	WB SD CRITFC	WB MEAN CRITFC	WB CV CRITFC
2,4,5-Trichlorophenol	92.6	257.2	36.0				92.6	257.2	36.0	65.3	353.9	18.4
2-Chloronaphthalene	4.4	13.4	32.6				4.4	13.4	32.6	27.6	30.4	91.0
2-Chlorophenol	86.2	265.4	32.5				86.2	265.4	32.5	65.3	353.9	18.4
Alpha-hexachlorocyclohexane	0.1	1.9	4.2	0.3	0.8	40.1	0.5	1.6	30.7	0.1	1.9	3.4
Aluminum	8016.2	7503.1	106.8	472.2	10160.0	4.6	7041.6	8135.7	86.6	64221.9	47350.0	135.6
Antimony	0.0	50.0		4.5	397.0	1.1	151.5	132.6	114.2	0.0	50.0	
Arsenic	122.0	302.5	40.3	749.6	1686.0	44.5	698.7	631.9	110.6	162.8	401.3	40.6
Beta-hexachlorocyclohexane	0.1	1.9	4.2	0.3	0.8	40.1	0.5	1.6	30.7	0.1	1.9	3.4
Cadmium	0.4	4.1	9.3	0.4	49.7	0.9	19.9	15.0	132.9	29.2	37.5	77.7
Chlordane (total)	14.7	13.5	108.7	1.2	3.4	35.7	14.1	12.1	115.8	14.9	16.4	91.1
Chromium	16.1	107.2	15.0	5815.2	7459.0	78.0	4130.2	1857.6	222.3	293.1	420.0	69.8
Copper	65.9	275.6	23.9	224.6	920.0	24.4	304.0	429.0	70.9	480.8	980.0	49.1
4,4-DDD	83.1	82.1	101.2	7.4	12.4	59.9	78.2	65.5	119.3	43.7	132.9	32.9
4,4-DDE	298.0	468.8	63.6	28.9	48.7	59.4	316.8	368.7	85.9	227.9	617.5	36.9
4,4-DDT	8.4	8.4	100.0	9.5	14.4	65.8	8.7	9.6	90.8	11.8	15.1	78.6
DDT (total)	9.0	11.1	81.8				9.0	11.1	81.8	13.4	16.9	79.4
Delta-hexachlorocyclohexane	0.1	1.9	4.2	0.5	1.1	49.5	0.4	1.7	26.1	0.1	1.9	3.4
Dieldrin				0.3	1.1	27.2	0.3	1.1	27.2			
Endosulfan I				1.7	1.8	98.5	1.7	1.8	98.5			
Endosulfan II				0.3	3.8	7.8	0.3	3.8	7.8			
Endosulfan Sulfate	0.1	1.9	4.5	0.1	3.7	2.3	0.8	2.4	34.2	0.1	1.9	3.4
Endrin				2.0	2.9	70.8	2.0	2.9	70.8			
Hexachlorobutadiene	3.0	7.1	42.2				3.0	7.1	42.2	13.8	15.2	91.2
Lead	2.5	10.6	23.5	12.6	55.5	22.7	20.5	21.3	96.2	106.2	121.3	87.6
Lindane(gamma-hexachlorocyclohexane	0.1	1.9	4.2	0.3	0.8	40.1	0.5	1.6	30.7	0.1	1.9	3.4
Mercury	132.3	152.8	86.6	89.0	241.7	36.8	127.3	174.0	73.2	63.0	145.0	43.5
Nickel	72.4	62.2	116.4	3540.3	3494.0	101.3	2180.4	879.3	248.0	655.5	407.5	160.9
PCBs (Total)	88.6	110.9	79.9	349.5	256.7	136.2	197.8	150.7	131.3	64.2	163.0	39.4
Pentachlorophenol	86.2	265.4	32.5				86.2	265.4	32.5	65.3	353.9	18.4
Selenium	648.6	1059.7	61.2	524.1	2072.0	25.3	752.1	1300.7	57.8	242.8	747.5	32.5
Silver	25.0	106.3	23.5	0.4	49.7	0.9	32.8	92.8	35.4	663.2	362.5	182.9
Toxaphene	2.3	56.7	4.0				2.3	56.7	4.0	1.6	57.4	2.8
	716.5	3790.6	18.9	1343.3	12530.0	10.7	3910.7	5871.4	66.6	2715.0	8237.5	33.0
Sample Size			n = 16			n = 5			n = 21			n = 8
Median			32.6			38.5			70.8			40.0
Mean			45.1			41.7			75.0			54.6
SD			37.9			34.9			55.3			48.5